THE U.S. NAVAL OBSERVATORY

STAR

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The Captain's Corner

CAPT Ben Jaramillo, Superintendent

As summer has come to an end, I want to thank all of you for your continued outstanding contributions to our USNO mission. Summer was a busy time for everyone but we did not skip a beat here at the Observatory. Your accomplishments have been many over the past several months and I continue to be impressed with the pride and professionalism I notice each and every day. I would especially like to give my thanks to those of you who interacted in any way with our summer students. You did a great job! I made it a point to meet with the students shortly after they arrived and before they departed. I also had a chance to sit in on the high school student presentations. To say the least, I was impressed with the quality of their presentations and the obvious mentoring and tutoring they received from you. I am glad to say that whether you played a small part or a large part in the day-to-day activities of the students they all left here with a favorable impression of what we do and how we do it. These were all young and impressionable students who had a great summer at the Observatory. Again, thanks to all.

A new fiscal year is upon us, and with that comes all of the last minute work to make sure last year's spending is completed and accounted for and that we are ready for the coming year. I ask all of you to work closely with your departments and RM in closing out another successful year. We have many things planned for next year none of which is probably more important at the moment as the official millennium celebration. Unlike last year, we will probably be the only official celebration other than the annual fireworks downtown. I know our committee is working hard to put on another celebration that all of you can participate in and be justly proud. Have a safe and productive fall season and I will see you around on my afternoon walks.

Gail Witcher Receives ASN (FM&C) and USNO Gilliss Awards

The Office of the Assistant Secretary of the Navy (Financial Manager and Comptroller) has honored USNO's Gail D. Witcher with its first annual Comptroller/Deputy Comptroller (Echelon 2 Commands and above) Award. She was also honored with the 2000 USNO James Gilliss Award for Outstanding Service. Her ASN award citation reads as follows:

"Ms. Witcher's achievements included: the integration of the Resources Management and Administration Departments, the regionalization of several departments within the Command's organization, major preparations for the Command Inspection and the Procurement Management Review. Her accomplishments have had an immediately positive command-wide impact. Her work on the MWR improved the Quality of Life for military and civilian employees. Her encouragement for employee self-improvement has had a great impact on the morale of her employees. Ms. Witcher personified great leadership characteristics in facing and resolving tough challenges in meeting and exceeding every operational and administrative command mission goal in every respect."

Congratulations, Gail!

In This Issue:

USNO to Celebrate New Millennium With Open House and Time Ball Drop

On New Year's Eve, December 31, 2000, the U.S. Naval Observatory will celebrate the beginning of the Third Millennium under the stars with a free Open House featuring music, displays, telescopic viewing of celestial objects (weather permitting), and a concluding celebration at the stroke of midnight. At that precise moment, a time ball will be released from a mast on the roof of the Observatory's Main Building, signaling the official arrival of the new millennium in the United States.

As was the case last year, this year's event is planned to include a formal reception for about 600 people, beginning at 8:00 pm. USNO employees will receive an invitation for themselves and a guest. Additional guests may attend for a fee to be determined later. Employees and guests who do not wish to attend the reception can attend the Open House beginning at 10:00 pm. About 3000 people will be admitted to this year's festivities.

Once on the grounds, visitors may view the Observatory's telescopes, tour the Master Clock facility, visit displays of USNO activities, enjoy musical entertainment, and view celestial sights through the Observatory's 12-inch telescope and others provided by local amateur astronomers. Light refreshments will be available.

The time ball drop will take place by order of the Secretary of the Navy, the Honorable Richard Danzig, to recreate a traditional Navy time signal to commemorate the beginning of the year 2001. As the ball descends, it will also trigger a cannon shot. The Naval Observatory dropped the first time ball in the United States in 1845, a tradition that continued until 1936. As with last year, the Secretary will give the signal to drop the time ball.

The U.S. Naval Observatory, which maintains the Master Clock of the United States, is also reactivating its around-the-world time ball drop, successfully carried out last New Years' Eve at 20 sites in 8 countries on 6 continents. As the new millennium sweep around the world beginning at the International Date Line, the drops will be coordinated with the Global Positioning System of satellites, for which the Naval Observatory provides the time.

Although many celebrated the new millennium last New Year's Eve, according to the Gregorian calendar it actually begins January 1, 2001. A digital clock at the main entrance to the Naval Observatory is still counting down to the millennium.

Determination and dissemination of time have been an essential part of the Naval Observatory mission since its beginning in 1830. During that time clock technology has evolved from precision pendulum clocks to quartz crystal clocks to the present hydrogen maser and cesium-beam atomic clocks. An even more accurate cesium fountain clock is under development at the Observatory. Similarly, time dissemination has evolved from the visual signal represented by the time ball, to the Global Positioning System (GPS), for which USNO supplies the time. Clock accuracy has advanced from one-thousandth of a second with the most elaborate pendulum clocks at the beginning of the century, to one billionth of a second per day with the present atomic clocks. Time dissemination, accurate to a few tenths of a second with the time ball, is now accurate to within a few billionths of a second with GPS.

The event is also part of the White House Millennium program, described at http://www.whitehouse.gov/Initiatives/Millennium.

New USNO Atomic Clock Realizes First Milestone

Tom Swanson, Time Service Department

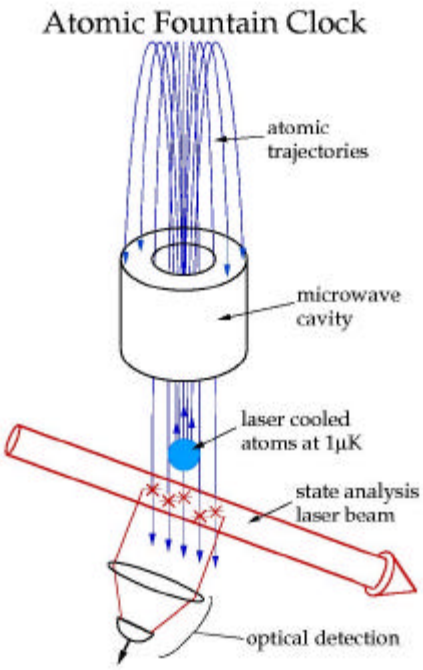
A team of USNO scientists, led by Drs. Christopher Ekstrom, Eric Burt, and Tom Swanson, has successfully completed the first stage of testing of a new type of atomic clock that will dramatically improve the precision of the USNO's Master Clock ensemble. This new clock, called a cesium fountain, has successfully demonstrated a frequency stability of better than 2×10^{-13} seconds.

The successful development and implementation of a cesium fountain timescale will improve the accuracy of the current Master Clock by one to two orders of

magnitude. This will translate into significantly greater positional accuracy and precise time distribution for users of Global Positioning System technology.

Background

Cesium atoms are widely used in atomic clocks. One of the transitions in Cesium has an oscillation frequency of 9,192,631,770 Hz, which is used to define the second. In a standard atomic clock, the cesium atoms in a hot beam are interrogated twice by microwave radiation. The first pulse starts the oscillation between two hyperfine states and a second, later pulse stops the oscillation. The information about the frequency of the microwaves is encoded in the population of the two states of the cesium. This type of clock is a passive device.



The Atomic Fountain

The fountain geometry increases the time between the two interrogations by gently tossing the atoms up and letting them fall back down under the influence of gravity, all under high vacuum. Atoms are collected and then launched through a single microwave cavity, which interrogates the atoms both on the way up and again on the way down. The atoms are then detected optically to determine the information about the microwave frequency. This cycle is then repeated. The longer time between interrogations improves the precision of the measurement, as does the use of a single microwave cavity.

Light pressure is used to manipulate the atoms: collect them, launch them at a controllable velocity, and keep them cold to minimize the expansion of the atom cloud during its ballistic flight.

The USNO Fountain Design Goals

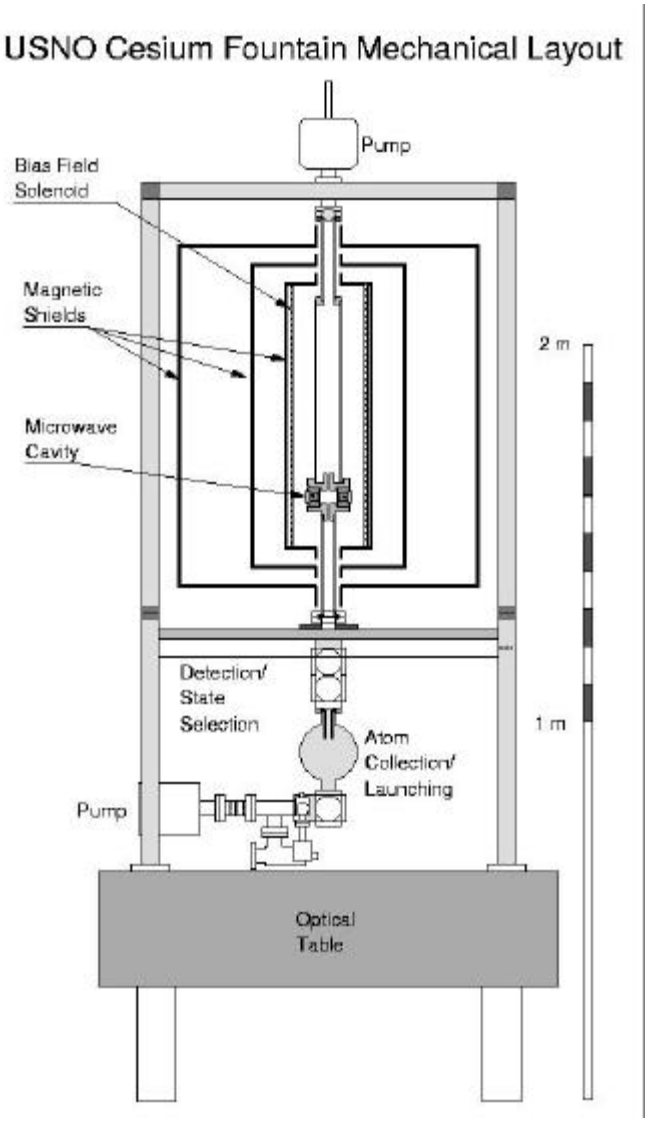
The USNO fountain is designed to be a reference device, not a primary frequency standard. In other words, our device does not have to "tick" at precisely one second (the job of defining the second is done by NIST), but it must be as stable as possible. This means that we must minimize fluctuations in factors that might affect the fountain, such as temperature, magnetic field, and number of atoms in the signal.

Short- and long-term performance goals

The short-term performance of the fountain is a combination of two factors: the interrogation time, which determines the spacing of the interference fringes generated by scanning the external microwave frequency, and the resolution of an individual fringe, which depends on the signal-to-noise ratio.

Our launching allows a one-half second interrogation of the atoms. This means that the interference fringe peaks will be spaced 2 Hz apart. If our microwaves are on the cesium resonance, this means we know the microwave frequency to better than 1 Hz, or about 1 part in 10^{10} (ten billion). We can generate signal-to-noise sufficient to resolve the fringe to about one part in a thousand, so our overall short-term performance is between one and two parts in 10^{13} (ten trillion) at one second.

As the clock runs over a period of time, we are able to average out any random noise that is present, so the performance improves until non-random (systematic) noise sources begin to dominate. This systematic floor depends on how well we limit fluctuations in the systematic noise terms, and a long-term performance of a few parts in 10^{16} should be achievable.



Astrometric survey of the Southern Hemisphere complete

Norbert Zacharias, Astrometry Department

Since January 1998 a dedicated 20-cm aperture astrograph has been operating at Cerro Tololo, Chile. This astrograph was brought from the U.S. Naval Observatory in Washington, DC for one purpose: to map the southern sky to derive highly accurate positions of stars in the 8th to 16th magnitude range. The goal is 20 milliarcsecond (mas) accuracy for positions of stars in the 10 to 14 magnitude range, with 70 mas at 16th mag. A single bandpass in the red (579-642 nm) is used, avoiding strong emission lines like H-alpha. What the telescope lacks in size, it compensates for by its wide field and high astrometric quality. The 9 degree diameter flat field focal plane of the 5-element red lens, obtained in 1993 from the Univ. of Arizona Optical Science Laboratory, is designed for photographic plates. Only a square degree is utilized by a 4k by 4k Kodak CCD, still the largest single chip on the mountain.

On 27 August, coverage of the entire Southern Hemisphere was completed with a 2-fold overlap pattern (center in corner) and 2 exposures (about 125 and 25 sec) per field. The survey started at the South Celestial pole and works its way north in a spiral pattern. In some hours of right ascension the survey is already up to +14 degrees declination. So far about 140,000 frames have been taken. The 2.2 terabytes of compressed raw data are saved to tapes and CD-ROM's (yes, about 3,500 of them). In addition, about 4 times a year, radio reference frame sources are observed simultaneously with deep astrograph and CTIO 0.9-meter exposures. This will provide a direct link between the radio and optical reference frames, to check on the alignment of the Hipparcos system. In early 2001 the instrument will be relocated to a northern site to complete the all-sky astrometric survey by mid 2003.

The first US Naval Observatory CCD Astrograph Catalog (UCAC1) was released in March 2000, containing preliminary positions and proper motions of over 27 million stars. Positions are on the International Celestial Reference System (ICRS), based on Tycho reference stars using mainly the ACT catalog.

Proper motions for the brighter stars are based on the Tycho-2, the Astrographic Catalogue (AC), and about 140 other ground-based catalogs. Preliminary proper motions for the faint UCAC1 stars have been derived utilizing the USNO A2.0 catalog.

UCAC data are currently been used by the 2MASS infrared survey and the Sloan Digital Sky Survey (SDSS). The position zero-point of the Hubble Deep Field South (HDF-S) is based on preliminary results

obtained with the astrograph. The UCAC project provides the much needed extension of the Hipparcos and Tycho system towards fainter magnitudes. Its high positional accuracy and density (on average 1700 stars per square degree) together with its sky coverage make it unique.

Many astronomical projects will benefit from the UCAC, including observations of minor planets, astrometric reductions of Schmidt plates, aligning radio and optical features in high resolution maps and placing fibers for spectroscopy of distant quasars at large telescopes. UCAC will also provide the basis for an input catalog of the FAME space mission.

The final catalog will utilize the Northern and Southern Proper Motion (NPM, SPM, Lick, Yale, San Juan) data. All applicable plates have already been scanned by the Precision Measuring Machine (PMM) at the USNO Flagstaff station. The UCAC project is explained in detail in an Astronomical Journal article (Zacharias et al.) which is scheduled for the October 2000 issue. Updates are posted on the Web at http://ad.usno.navy.mil/ucac/.

Security Notes

USNO POLICE EMERGENCY NUMBERS

34th Street Gate (24 Hours): 762-1468

Shift Lieutenant: 762-0336

Shift Sergeant: 762-0338

Local Emergency Number: Dial 99 + 911.

When calling the local emergency number please notify the USNO police in order to escort the emergency personnel and vehicles to the scene.

GATES (Hours of Operation):

34th Street Gate: Open 24 Hours/7 Days Per Week

South Gate: Open Monday through Friday, 0545 - 1830

Wisconsin Gate: Closed until further notice

Davis Street Gate: Closed

Gilliss Avenue Gate: Opened as Directed, otherwise closed

Wisconsin Turnstile: 24 Hours Daily (Must have USNO Swipe Card to re-enter)

USNO In The News

Geoff Chester, Public Affairs

It's been a relatively quiet summer news-wise for USNO. The Vice President has been interviewed in the Library of several occasions, most recently by Tim Russert for NBC's *Meet The Press.*

The Hubble Heritage image of NGC 6751, for which Arsen Hajian was the principal investigator, was highlighted on the editorial page of the September issue of *Astronomy*.

A film crew from the Discovery Science Channel spent several days at the Observatory documenting the USNO's role in precise timekeeping and the development of the Cesium Fountain. This will be a segment in a science-news digest program that will air this fall.

The Public Affairs Office is getting geared up for the Millennium Celebration on New Year's Eve. We receive almost daily inquiries about the "true" Millennium. We are also anticipating many inquiries as the Leonid meteor shower approaches in November.

Vice President Gore and Tim Russert relax with a plate of Nashville barbecue after their encounter on Meet The Press

ABSTRACTS OF RECENT PAPERS:

BINARY STAR DIFFERENTIAL PHOTOMETRY USING THE ADAPTIVE OPTICS SYSTEM AT MOUNT WILSON OBSERVATORY

Theo ten Brummelaar, Brian D. Mason, Harold A. McAlister, Lewis C. Roberts Jr., Nils H. Turner, William I. Hartkopf, and William G. Bagnuolo Jr.

The *Astronomical Journal,* Vol. 119, Pg. 2403, May 2000

We present photometric and astrometric results for 36 binary systems observed with the natural guide star adaptive optics system of the Mount Wilson Institute on the Hooker 100-in telescope. The measurements consist of differential photometry in U, B, V, R and I filters along with astrometry of the relative positions of system components. Magnitude differences were combined with absolute photometry found in the literature of the combined light for systems to obtain apparent magnitudes for the individual components at standard bandpasses, which in turn led to color determinations and spectral types. The combination of these results with Hipparcos parallax measurements yielded absolute magnitudes and allowed us to plot the components on an HR diagram. To further examine the reliability and self-consistency of these data, we also estimated system masses from the spectral types.

PRELIMINARY RESULTS FROM THE USNO CESIUM FOUNTAIN

Thomas B. Swanson, U. S. Naval Observatory, Washington, D. C.
Eric A. Burt, U. S. Naval Observatory, Washington, D. C.
Christopher R. Ekstrom, U. S. Naval Observatory, Washington, D. C.

Submitted to the IEEE Frequency Control Symposium, to be published in the proceedings of the 2000 FCS conference.

Abstract:

We are pursuing a program that will integrate atomic fountain-based clocks into the U. S. Naval Observatory (USNO) Master Clock. We will present data from our cesium atomic fountain, including initial measurements of our device relative to an active hydrogen maser on both the clock transition and a magnetic field sensitive transition. As this maser is part of the USNO timing ensemble, we can easily relate the frequency and frequency stability of the fountain to any of our clocks or internal timescales. We will also present several possible continuous operation strategies for the incorporation of this new class of clock into the local clock ensemble.

Asteroids and Craters Named for USNO Staff members

Geoff Chester, Public Affairs Office

At the recent retirement of Alan Fiala, one of the more unusual gifts presented to him was an asteroid bearing his name. Alan joins a long list of USNO staff members who have been so honored. Librarian Brenda Corbin has compiled a list of these objects, to which I have added a list of USNO staff who have craters named for them on the Moon and other celestial bodies. I have also compiled a list of asteroids discovered by USNO staff. If anyone has any additions or corrections, I'd be most interested in them.

Asteroids discovered by USNO staff:

31	Euphrosyne	by James Ferguson
	(First US asteroid discovery)	
50	Virginia	by James Ferguson
60	Echo	by James Ferguson
536	Merapi	by G. H. Peters
886	Washingtonia	by G. H. Peters
980	Anacostia	by G. H. Peters

Asteroids named for USNO staff:

855	Newcombia	Simon Newcomb
1575	Winifred	Winifred Sawtelle
1642	Hill	G. W. Hill
1657	Roemera	Elizabeth Roemer
1745	Ferguson	James Ferguson
1750	Eckert	Wallace Eckert
1798	Watts	Chester B. Watts
1919	Clemence	G. Clemence

2023	Asaph	Asaph Hall
2974	Holden	Edward S. Holden
2796	Kron	G. Kron
3118	Claytonsmith	Clayton Smith
3160	Angerhofer	Phil Angerhofer
3216	Harrington	Bob Harrington
3217	Seidelmann	Ken Seidelmann
3225	Hoag	Art Hoag
3236	Strand	K. Aa. Strand
3299	Hall	John S. Hall
3368	Duncombe	Raynor Duncombe
3633	Mira	Hugo Mira (Observer for USNO at El Leoncito, Argentina)
3695	Fiala	Alan Fiala
3743	Pauljaniczek	Paul Janiczek
4008	Corbin	Tom and Brenda Corbin
5036	Tuttle	Horace P. Tuttle
5175	Ables	Harold Ables
5105	Westerhout	Gart Westerhout
5367	Sollenberger	Paul Sollenberger
5951	Alicemonet	Alice Babcock Monet
5962	Davemonet	David G. Monet
6696	Eubanks	Marshall Eubanks
6363	Doggett	LeRoy Doggett
6375	Fredharris	Frederick H. Harris
6909	Levison	Harold Levison (USNO contract employee)
7011	Worley	Charles Worley

Lunar Craters named for USNO staff:

Eckert	Wallace Eckert
Hall	Asaph Hall
Hill	G. W. Hill
Holden	Edward S. Holden
Maury	Matthew F. Maury
Newcomb	Simon Newcomb
Ritchey	George W. Ritchey
Watts	Chester B. Watts

Craters on other solar system bodies

Hall	(Phobos)	Asaph Hall
Stickney	(Phobos)	Angeline Stickney Hall (wife of Asaph)

Ground-Source Heat Pump Installed in Building 1

Geoff Chester, Public Affairs

USNO's historic Building 1 has always been the envy of almost everyone who visits. However, anyone who has ever spent any time in Building 1 soon realizes that comfort was probably not one of the major concerns of the 19th Century builders. The office spaces were usually hot in the summer, and over the past few years even hotter in the winter thanks to individual air conditioning units and an overly zealous central heater.

This has all changed now thanks to the new ground-source heat pump system, which was phased into operation as the summer ended.

The system essentially uses the earth as a source for heating and cooling, via a network of 50 deep wells drilled into the north lawn. Coolant circulating through the wells provides heat in the winter and cooling in the summer to each office via dedicated individual heat pumps regulated by automatic thermostats.

The well field as it appeared in the spring (above), and after re-seeding this fall.

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